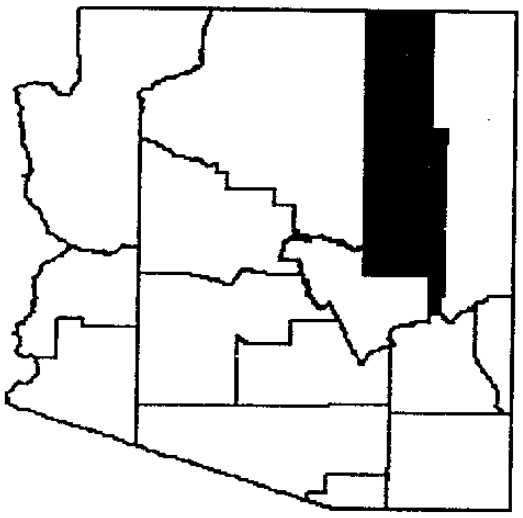
FLOOD INSURANCE STUDY

NAVAJO COUNTY, ARIZONA
UNINCORPORATED AREAS



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NOTICE TO
FLOOD INSURANCE STUDY USERS

Communities participating in the National Flood Insurance Program have established repositories of flood hazard data for floodplain management and flood insurance purposes. This Flood Insurance Study may not contain all data available within the repository. It is advisable to contact the community repository for any additional data.

This publication incorporates revisions to the original Flood Insurance Study. These revisions are presented in Section 9.0.

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Flood Boundary and Floodway Map

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FLOOD INSURANCE STUDY
NAVAJO COUNTY, ARIZONA UNINCORPORATED AREAS

1.0 INTRODUCTION

1.1 Purpose of Study

This Flood Insurance Study (FIS) investigates the existence and severity of flood hazards in the unincorporated areas of Navajo County, Arizona, and aids in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. This study will be used to convert Navajo County to the regular program of flood insurance by the Federal Emergency Management Agency (FEMA). Local and regional planners will use this study in their efforts to promote sound floodplain management.

In some States or communities, floodplain management criteria or regulations may exist that are more restrictive or comprehensive than those on which these federally supported studies are based. These criteria take precedence over the minimum Federal criteria for purposes of regulating development in the floodplain, as set forth in the Code of Federal Regulations at 24 CFR, 1910.1(d). In such cases, however, it shall be understood that the State (or other jurisdictional agency) shall be able to explain these requirements and criteria.

1.2 Authority and Acknowledgments

The source of authority for this FIS is the National Flood Insurance Act of 1968, as amended.

The hydrologic and hydraulic analyses for this study were performed by Cella, Barr Associates, for FEMA, under Contract No. H-4607. This work, which was completed in August 1980, covered all significant flooding sources affecting Navajo County.

1.3 Coordination

The Consultation Coordination Officer (CCO), appointed by FEMA, organized the first community meeting held on August 8, 1977. This meeting, attended by representatives of Navajo County, FEMA, and the Study Contractor (SC), was held to explain the nature and purpose of the FIS.

The Arizona Water Commission served as the State coordinating agency for this study.

Contact was maintained during the course of this study with the U.S. Geological Survey (USGS), the U.S. Army Corps of Engineers, (USACE), the U.S. Soil Conservation Service (SCS), the Arizona Department of Transportation (ADOT), the Director of the Navajo County Engineering Department, and the Navajo County Planning and Zoning Administrator.

On July 24, 1980, the results of this study were reviewed at an intermediate/final CCO meeting which was attended by representatives of Navajo County, FEMA, and the SC. No changes were made to the study as a result of this meeting.

2.0 AREA STUDIED

2.1 Scope of Study

This FIS covers the unincorporated areas of Navajo County, Arizona. The area of study is shown on the Vicinity Map (Figure 1).

Areas not included in this study are the incorporated Cities of Winslow, Holbrook, and Show Low and the Towns of Taylor and Snowflake. Also not included are the Navajo, Hopi, and Fort Apache Indian Reservations and the Navajo—Hopi Joint Use Area.

The following streams were studied by detailed methods: Billy Creek (near Lakeside); Black Canyon Wash (near Heber); Buckskin Wash (near Heber); Little Colorado River (near Holbrook, Winslow, and Woodruff); Pinedale Wash (near Pinedale); Porter Canyon Draw (near Holbrook); Show Low Creek (near Show Low); Silver Creek (near Show Low and Shumway); Town Wash (near Clay Springs); Walnut Gulch Creek (near Pinetop); and Whiting Creek (near Holbrook). Various other streams throughout the county were studied by approximate methods.

Those areas studied by detailed methods were chosen with consideration given to all proposed construction and forecasted development through 1985.

Approximate analyses were used to study those areas having a low development potential or minimal flood hazards. The scope and methods of study were proposed to and agreed upon by FEMA and Navajo County.

2.2 Community Description

Navajo County is in northeastern Arizona. It is approximately 212 miles long and 47 miles wide. A 6—mile—wide strip borders Apache County for an additional 30 miles in the southeast corner. Navajo County is bordered to the north by San Juan County, Utah;

to the south by Gila and Graham Counties; to the east by Apache County; and to the west by Coconino County. Total area of the county is approximately 6,343,400 acres, or 9,910 square miles. Holbrook, the county seat, is 150 miles northeast of Phoenix. The other large towns are Show Low, Winslow, and Snowflake. The 1970 population of the county was approximately 47,560; the 1978 population estimate was 71,000 (Reference 1). The major growth areas include Snowflake-Taylor, Show Low, and the unincorporated resort areas of Pinetop and Lakeside. Land ownership and administration in 1970 were as follows: individual and corporate, 1,194,000 acres; State, 327,000; national forests, 488,000; Bureau of Land Management, 97,000; National Park Service, 23,000; and Indian trust, 4,214,000.

The highest elevations within the county are approximately 7,000 to 8,300 feet on the Black Mesa in the northern part of the county and 6,500 to 7,500 feet along the Mogollon Rim in the southern part of the county. The lowest point is approximately 4,800 feet, north of Winslow. The Little Colorado River network drains all but the extreme southern and northern parts of the county. The physiography of the county consists of slightly to strongly dissected high plains underlain predominantly by sandstone and shale bedrock. An area in the extreme southern tip of the county and another north of Pinetop are dominated by basaltic rocks. A third area, lying approximately 50 miles north of Holbrook, is also dominated by volcanic materials consisting of basalt-capped mesas, cinder cones, and exposed volcanic necks. Approximately 18 percent of the county consists of strongly dissected Badlands and rough broken lands in shaly materials that contribute large amounts of sediment to the drainage system (Reference 2). Annual precipitation ranges from approximately 8 inches near Winslow to 30 inches or more along the Mogollon Rim. The vegetation types are strongly influenced by the amount of precipitation. Cover on the Black Mesa is generally pinyon pine and juniper with an understory of brush and grasses. In the lower, drier sites, the vegetation is sparse stands of brush and short grasses. Farther south, approaching the Mogollon Rim, vegetation again is pinyon, juniper, brush, and grass, with Ponderosa Pine forests in the zones of higher precipitation and elevation along the Mogollon Rim. Concentrated development within flood hazard areas has occurred only in the vicinity of the communities of Holbrook and Winslow along the Little Colorado River.

- **Winslow Area.** Several homes have been constructed within the floodplain areas of the Little Colorado River outside the corporate limits of Winslow. Winslow is located along the western border of Navajo County and is situated approximately 35 miles east of Flagstaff along Interstate Highway 40 (I-40). The vegetation surrounding the community consists mostly of sparse desert brush and small shrubs. The climate is basically warm and semiarid. The principal rainy season is midsummer, generally beginning in June and continuing through September. Soils of the region are classified as Type C indicating slow infiltration rates when thoroughly wetted (Reference 2).

- **Holbrook Area.** The Little Colorado River and its major tributary, the Puerco River, drain an area of approximately 11,300 square miles above Holbrook. Elevations within the drainage area range from 11,500 feet at Mt. Baldy southwest of Springerville to just under 5,100 feet at Holbrook. The Holbrook study area lies in a shallow desert valley. Except for large trees and shrubs associated with the riparian community, the vegetation is sparse, with grasses and small shrubs dominating the area. The climate is similar to that of Winslow, warm and semiarid with normal annual precipitation averaging 8 inches. Soils of the region are classified as Type C with a slow infiltration rate (Reference 2). Holbrook is an important trading center at the junction of several transportation lines in addition to being a service center for travelers and surrounding ranches and farms. It is the Navajo County seat. The economy of the region is based on Federal, State, and local government agencies; wholesale and retail trade; light manufacturing; and retail services.

- **Woodruff.** The unincorporated community of Woodruff is located approximately 15 miles southeast of Holbrook off State Highway 77 (SH 77). No population statistics are available for the Woodruff area; however, it is estimated that fewer than 100 people comprise this community. The elevation at Woodruff is approximately 5,700 feet. Woodruff is located within the high desert areas of northern Arizona. The surrounding vegetation is comprised mostly of sparse grasses and small shrubs. The climate, topography, and soils are very similar to the Holbrook area. The Little Colorado River is the major river system passing through the community. At Woodruff, the Little Colorado River is characterized by a highly incised stream channel with relatively narrow floodplain widths. Historically, flooding along the river has presented very few problems.

- **Shumway.** The small unincorporated community of Shumway is located approximately 5 miles south of the Town of Taylor along SH 77. No population information is available for Shumway; however, it is estimated that fewer than 100 people comprise this community. Shumway is located within a transition zone between the high plateau deserts and the White Mountain pine forest. The surrounding vegetation is characteristically juniper and grasslands. Climate of the area is basically warm and semiarid; however, winter temperatures drop significantly. Mean daytime temperatures during the winter months average 45°F. The mean annual precipitation is approximately 10 inches at Shumway. Soils of the area are Type C with a low infiltration capacity (Reference 2). The community of Shumway Silver Creek, one of the major tributaries to the Little Colorado River. Historical floodflow records indicate several large-magnitude flows along Silver Creek during the recent past. Several homes have been constructed near the floodplain fringes of Silver Creek; however, little damage has occurred during historical floodflows.

- **Lakeside–Pinetop.** The unincorporated communities of Lakeside and Pinetop are located approximately 15 miles south of the City of Show Low on State Highway 260 (SH 260). The climate in this area is basically that of the cooler mountainous regions of northern Arizona. Normal annual precipitation is approximately 21 inches. The principal precipitation is in the form of snow during the winter months. The surrounding vegetation is predominantly Ponderosa Pine forest. Soils in the area are Type B with moderate infiltration rates when thoroughly wetted (Reference 2). The principal stream systems near Lakeside and Pinetop are Billy Creek and Walnut Gulch Creek, respectively. The communities of Lakeside and Pinetop have relatively few significant flooding problems. Many of the stream channels in this area are highly incised and contained within well defined limits. In 1970, the combined population of these communities was approximately 2,600. The 1978 population estimate for the Lakeside–Pinetop area was 4,800 (Reference 1). Recent population increases and the pressure for land development have resulted in some homes being constructed within the flood hazard areas of local washes.

- **Pinedale–Clay Springs.** The unincorporated communities of Pinedale and Clay Springs are located approximately 15 miles west of the City of Show Low along SH 260. No population information is available for the communities of Pinedale and Clay Springs; however, it is estimated that their combined population is approximately 200 people. Pinedale and Clay Springs are within the high mountainous regions of northern Arizona. The surrounding vegetation is mostly Ponderosa Pine, with some juniper. The climate of the area is cool; daytime summer temperatures average 72°F and daytime winter temperatures average 40°F. Soils of the area are comprised of Type B with moderate infiltration rates (Reference 2). The principal stream system near the community of Pinedale is Pinedale Wash. At the time of this study, no homes or businesses had been constructed within the floodplain areas of this wash. The principal stream channel through the community of Clay Springs is Town Wash, a small mountain stream with a basin area of approximately 3.5 square miles. Some homes have been constructed within the floodplain areas of Town Wash; however, historically, flooding has created very few problems.

- **Heber.** The unincorporated community of Heber is located approximately 45 miles west of the City of Show Low on SH 260. The 1970 population for this community was 1,100. The 1978 population estimate for the Heber area was 1,350 (Reference 1). Heber is located within the high mountainous regions of northern Arizona. The surrounding vegetation is comprised of Ponderosa Pine forest. The average annual precipitation is approximately 23 inches. The principal precipitation is in the form of snow during the winter months. Soils of the area are Type B with moderate infiltration rates (Reference 2). The community of Heber is located near the confluence of two major washes, Buckskin Wash and Black Canyon Wash. These stream channels are relatively well incised and, as a result, few homes have been constructed within extreme flood hazard areas.

2.3 Principal Flood Problems

A brief outline of the particular flooding problems of each community was provided in Section 2.2 (above) of this report. With the exception of those developments within the floodplain areas of the Little Colorado River adjacent to the City of Winslow, the flooding problems in these communities are relatively minor. Near Winslow, several homes within the Bushman Acres and Ames Acres subdivisions were constructed within the flood hazard areas of the Little Colorado River. These subdivisions experience flooding quite frequently, as most of these homes are within the 10-year floodplain of the Little Colorado River. Historical floodflow records for the Little Colorado River indicate floodflow magnitudes between 19,700 cubic feet per second (cfs) and 60,000 cfs between 1923 and 1978, as recorded at the USGS gage (No. 3970) at River Mile (RM) 189.99. These discharge values have return periods of between 10 and 80 years, as determined from stream-gage records compiled by the USACE and their subsequent floodflow frequency analysis (Reference 3)

Historical floodflow data for the Little Colorado River at Holbrook are as follows:

Date	Annual Peak Discharge (cfs)
September 19, 1923	60,000
October 4, 1969	24,200
August 5, 1957	21,800
August 12, 1968	21,000
September 6, 1970	19,700
October 1, 1971	20,300

Figures 2 through 7 are photographs of the December 1978 flood of the Little Colorado River at Winslow. The December 1923 flood was the maximum flood of record. The USGS doe not operate a stream gage at Winslow; however, because of the severity of the December 1978 flood, a discharge of 57,500 cfs was computed for the Little Colorado River from stream gages located on tributary channels (Clear Creek and Chevelon Creek) that generated most of that flow.

Because of the incised stream channel, flooding along the Little Colorado River near Woodruff has presented very few problems to life and property. The USGS operates a recording stream gage (No. 3945) at RM 203.01 near Woodruff. The record of historical floodflows at this location is as follows:

Date	Annual Peak Discharge (cfs)
December 5, 1919	25,000
July 21, 1929	10,700
February 10, 1932	10,200
July 26, 1940	13,000
January 19, 1952	10,200
December 19, 1978	9,320

2.4 Flood Protection Measures

Several flood-control structures have been constructed in the Winslow area to eliminate or reduce the magnitude of existing flood hazards. Approximately 0.25 mile north of the City of Winslow, Navajo County has constructed a levee of varying cross-section dimensions along the Little Colorado River. The construction of this levee has been completed in various stages and is not on a set schedule. It does not meet FEMA levee standards. The upstream limit of the levee is approximately 1,000 feet north of the Interstate Highway 40 (I-40) alignment. Thus, floodwater conveyed beneath the I-40 bridge may immediately enter the overbank area west of the Little Colorado River channel alignment and inundate several residential, industrial, and agricultural properties. In its present state, the county levee appears to do very little, if anything, to protect residents of this area from their existing flood hazards of greater than 5-year frequency along the Little Colorado River. This is evident by the periodic flooding of lands west of the county levee during historical floodflow events. The main purpose of the levee appears to be the stabilization of the horizontal alignment of the Little Colorado River channel. The highly erosive fine-grained soils of the area have resulted in significant damage to property near the river during historic events. In order to prevent this bank erosion, used cars were tied together and placed on the east slope of the levee.

Figure 2. Major Levee Erosion Resulting From Floodwaters in Little Colorado River During December 1978

Figure 3. Break in Existing Earth Levee Along the West Side of Little Colorado River, December 1978

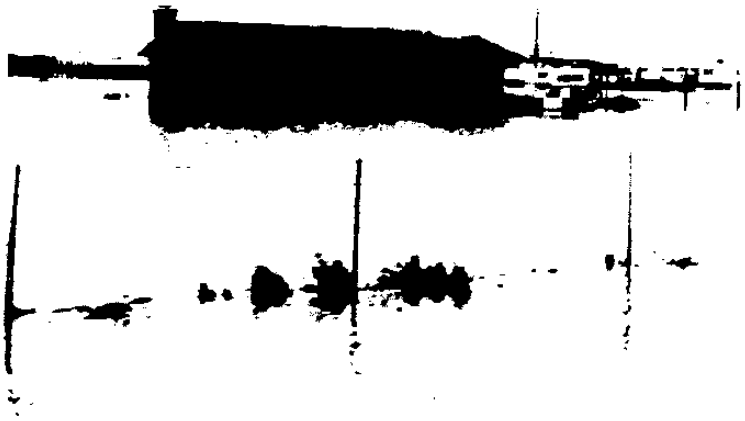

Figure 4. Residential Flooding in Bushman Acres, December 1978

Figure 5. Street Flooding in Bushman Acres, December 1978

Figure 6. Residential Flooding in Winslow Plaza, December 1978

Figure 7. Flooding in Ames Acres, December 1978

The USACE has constructed a flood-control levee along the Little Colorado River at Holbrook. This structure has been in place since 1948. At that time, the levee was designed to protect Holbrook and county lands north of the river from floods of up to 60,000 cfs (approximately the 100-year flood). Because of sediment buildup on the channel bottom, it is estimated that a flow of approximately 28,000 cfs could overtop the levee and cause flooding in Holbrook. No flooding has occurred north of the levee since it was built; however, no floods in excess of 28,000 cfs have occurred since its construction.

No flood-control structures have been constructed in the communities of Woodruff, Shumway, Lakeside, Pinetop, Pinedale, Clay Springs, or Heber for the purpose of eliminating or reducing the magnitude of existing flood hazards.

County officials intend to adopt an ordinance to delineate areas of flood hazard or to prohibit development in flood hazard areas based on the results of this FIS. No other floodplain management measures exist.

3.0 ENGINEERING METHODS

For the flooding sources studied in detail in the county, standard hydrologic and hydraulic study methods were used to determine the flood hazard data required for this study. Flood events of a magnitude that are expected to be equaled or exceeded once on the average during any 10-, 50-, 100-, or 500-year period (recurrence interval) have been selected as having special significance for floodplain management and for flood insurance premium rates. These events, commonly termed the 10-, 50-, 100-, and 500-year floods, have a 10-, 2-, 1-, and 0.2-percent chance, respectively, of being equaled or exceeded during any year. Although the recurrence interval represents the long-term, average period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than 1 year are considered. For example, the risk of having a flood that equals or exceeds the 100-year flood (1-percent chance of annual occurrence) in any 50-year period is approximately 40 percent (4 in 10), and, for any 90-year period, the risk increases to approximately 60 percent (6 in 10). The analyses reported here reflect flooding potentials based on conditions existing in the county at the time of completion of this study. Maps and flood elevations will be amended periodically to reflect future changes.

3.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish the peak discharge-frequency relationships for floods of the selected recurrence intervals for each flooding source studied in detail affecting the county.

Peak discharges established by the USACE were used for the Little Colorado River near Winslow (Reference 4) and Holbrook (Reference 3). Peak discharges for the Little Colorado River near Woodruff were determined using Methods for Estimating the Magnitude and Frequency of Floods in Arizona (Reference 5).

The determination of peak discharge values for Silver Creek utilized flood data from four gaging stations. These gaging stations are located on the Little Colorado River above Lyman Reservoir (USGS gage No. 3840, with 38 years of record); along Chevelon Creek below Wildcat Canyon (USGS gage No. 3975, with 23 years of record); along Silver Creek below the confluence with Cottonwood Wash (USGS gage No. 3935, with 36 years of record); and on the Little Colorado River at Woodruff (USGS gage No. 3945, with 53 years of record). Historical floodflow data compiled at these gaging station locations were used to compute a regional log-Pearson Type III (Reference 6) frequency distribution. This procedure was required because of the paucity of local data.

Historical floodflow data compiled at the USGS gage No. 09-390500 at Lakeside were used to compute a regional log-Pearson Type III frequency distribution for peak discharges for the lower reach of Show Low Creek below the approximate elevation of 6,340.

For the remaining detailed study streams, peak discharge values for the various return periods were based on a floodflow frequency analysis compiled by the SC. The hydrologic analysis utilized regional information, historical floodflow records from several gaging stations in the region, and techniques presented in an ADOT publication (Reference 5) and the SCS computer program TR-20 (Reference 7).

Peak discharge values for streams studied by approximate methods were developed on the basis of an average expected discharge per acre from the contributing basin areas. Floodplain boundaries were developed from aerial photography (Reference 8) and field surveys to define topographic boundaries with specific consideration of expected flows.

Peak discharge-drainage area relationships for each flooding source studied in detail are shown in Table 1.

3.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of the flooding sources studied in the community were carried out to provide estimates of the elevations of floods of the selected recurrence intervals along each of these flooding sources.

Table 1. Summary of Discharges

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (Cubic Feet per Second) 10-Year	50-Year	100-Year	500-Year
Black Canyon Wash					
Immediately Below Confluence With Buckskin Wash	70.85	4,940	10,240	13,250	22,800
At State Highway 260	40.45	2,920	6,040	7,820	13,000
Buckskin Wash					
At State Highway 260	30.00	2,450	3,830	6,770	12,400
Approximately 1.45 miles upstream of Highway 260	28.60	N/A	N/A	6,530	N/A
Little Colorado River					
At Interstate Highway 40	16,000.0	36,400	55,900	65,000	109,000
At State Highway 77	11,300.0	26,000	45,000	54,000	79,000
At Canary Avenue	8,100.0	8,400	19,500	26,000	45,600
Pinedale Wash					
At Pinedale Road	5.25	680	1,690	2,270	4,500
Porter Canyon Draw					
At McLaws Road	93.63	5,660	9,570	11,640	17,000
Rocky Arroyo					
At the Confluence With White Mountain Lake	37.75	--[1]	--[1]	5,539	--[1]
Show Low Creek					
At South Corporate Limits With City of Show Low	81.4	--[1]	--[1]	16,890	--[1]
Below Jaques Dam	73.6	--[1]	--[1]	14,226	--[1]
Inflow to Show Low Lake at USGS Gaging Station 09-390500	68.3	--[1]	--[1]	13,321	--[1]
Silver Creek					
Downstream of Confluence With Cottonwood Wash	489	2,900	8,000	12,850	27,000
Upstream of Confluence With Cottonwood Wash	217	2,460	5,555	9,640	15,000
At Outlet With Mexican Lake	114.25	--[1]	--[1]	9,350	--[1]
Lower Silver Creek					
At Shumway Road	187.45	5,100	12,000	16,000	28,600
Immediately Below Confluence With Show Low Creek	410	8,400	19,500	26,000	45,600
Upper Silver Creek					
At Confluence With White Mountain Lake	55.83	--[1]	--[1]	12,200	--[1]

[1]Not Available

Table 1. Summary of Discharges (Cont'd)

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (Cubic Feet per Second) 10-Year	50-Year	100-Year	500-Year
Town Wash					
At Old State Highway 260	2.90	480	1,215	1,645	3,080
Walnut Gulch Creek					
At Stream Mile 2.21	3.23	480	1,190	1,600	2,960
Whiting Creek					
At Hill Road (Holbrook)	1.95	378	669	815	2,176
Ruby Wash					
At Outlet From Spreading Basin at North Park Drive South of McHood Road	27.8	_ 1	_ 1	4,219	_ 1
At North Park Drive	15.9	_ 1	_ 1	2,222	_ 1
Upstream of Interstate Highway 40	12.8	_ 1	_ 1	1,365	_ 1
At Santa Fe Railroad Crossing	12.5	_ 1	_ 1	1,293	_ 1
Oklahoma Flat Draw					
At North End of Study Limit	8.52	_ 1	_ 1	5,244	_ 1
At Confluence of Main Channel and Oklahoma Flat Flows	7.46	_ 1	_ 1	4,860	_ 1
Upstream of Twin 4-foot by 8-foot Box Culvert Under State Highway 260	3.30	_ 1	_ 1	2,918	_ 1
Entering Pine Crest Lakes Development (South of State Highway 260 and Old Crook Road)	3.05	_ 1	_ 1	2,671	_ 1

[1]Not Available

Flood elevations for the streams studied by detailed methods were determined using the USACE HEC-2 computer program for the computation of water-surface profiles (Reference 9). In order to simulate the character of stream channels and their adjacent overbanks, cross sections were compiled using topographic maps at a scale of 1:2,400, with a contour interval of 2 feet (References 10 and 11), for the stream channels to be studied by detailed methods. Stream channel geometry used in this floodplain analysis was developed specifically for this FIS. Aerial photogrammetric methods were used to compile the topographic maps of the stream channels and adjacent floodplain areas for developing the cross-sectional geometry (References 10 and 11).

Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles (Exhibit 1). For stream segments for which a floodway was computed (see Section 4.2), selected cross-section locations are also shown on the Flood Boundary and Floodway Map (FBFM)(Exhibit 2)

Roughness factors (Manning's "n") used in hydraulic computations were chosen by engineering judgment and based on field observations of the streams and floodplain areas. A summary of the Manning's "n" values used for floodplain modeling of the streams studied in detail is shown in Table 2. The dimensions of structures that produce backwater were identified through field measurements.

Starting water-surface elevations (WSELs) for the Little Colorado River at Holbrook, Whiting Creek, and Porter Canyon Draw were determined by normal-depth calculations. Starting WSELs for all other detailed study streams were determined by critical depth calculations.

Flood profiles were drawn showing computed WSELs to an accuracy of 0.5 foot for floods of the selected recurrence intervals (Exhibit 1).

The hydraulic analyses for this study were based on unobstructed flow. The flood elevations shown on the profiles are thus considered valid only if hydraulic structures remain unobstructed, operate properly, and do not fail.

Because of the shallow nature of flooding along the downstream portion of Whiting Creek, no profile for it is shown in this study.

All elevations are referenced to the National Geodetic Vertical Datum of 1929 (NGVD). Elevation reference marks (ERMs) used in the study are shown on the maps.

Table 2. Manning's "n" Values

Name of Stream	Reach (River Miles)	Overbanks	Channel
Black Canyon Wash (Near Heber)	15.80 – 18.31	0.045	0.030
Buckskin Wash (Near Heber)	0.00 – 1.54	0.045	0.030
	1.54 – 3.43	0.045 – 0.060	0.030 – 0.050
Little Colorado River (Near Winslow)	152.60 – 159.66	0.050	0.030
	159.66 – 159.69	1.50	0.030
	159.69 – 160.00	0.050	0.030
	160.00 – 160.10	0.040*,0.050	0.030
Little Colorado River (Near Holbrook)	183.70 – 186.21	0.045	0.035
	186.21 – 187.37	0.055,0.060*	0.035
	187.37 – 189.87	0.100	0.035
	189.87 – 191.45	0.045	0.035
	191.45 – 192.70	0.100	0.035
Little Colorado River (Near Woodruff)	201.50 – 202.08	0.050	0.030
	202.08 – 202.18	0.058	0.040
	202.18 – 202.41	0.060,0.055*	0.040
	202.41 – 202.71	0.050	0.030
	202.71 – 202.81	0.060	0.055
	202.81 – 202.99	0.055	0.030
	202.99 – 203.22	0.050	0.030
Pinedale Wash (Near Pinedale)	1.10 – 2.14	0.045	0.040
Porter Canyon Draw (Near Holbrook)	0.10 – 1.22	0.055	0.030
Show Low Creek (Near Show Low)	20.04 – 20.39	0.062	0.040 – 0.045
Silver Creek (Near Snowflake)	18.14 – 22.80	0.050*,0.130	0.041 – 0.045
Silver Creek (Near Shumway)	27.37 – 32.63	0.040	0.027

*Right Overbank

Table 2. Manning's "n" Values (cont'd)

Name of Stream	Reach (River Miles)	Overbanks	Channel
Town Wash (Near Clay Springs)	7.6 – 8.61	0.040	0.030
Walnut Gulch Creek	2.21 – 3.45	0.040	0.035
Whiting Creek (Near Holbrook)	0.65 – 1.43	0.055	0.030

4.0 FLOODPLAIN MANAGEMENT APPLICATIONS

The National Flood Insurance Program (NFIP) encourages State and local governments to adopt sound floodplain management programs. Therefore, each FIS includes a floodplain boundary map designed to assist communities in developing sound floodplain management measures.

4.1 Floodplain Boundaries

In order to provide a national standard without regional discrimination, the 100-year flood has been adopted by FEMA as the base flood for purposes of floodplain management measures. The 500-year flood is employed to indicate additional areas of flood risk in the community. For each stream studied in detail, the boundaries of the 100- and 500-year floods have been delineated using the flood elevations determined at each cross section; between cross sections, the boundaries were interpolated using topographic maps at a scale of 1:2,400, with contour intervals of 2 and 4 feet (References 10 and 11, respectively).

The floodplain boundaries for approximate-study streams were delineated using aerial photographs at a scale of 1:8,400 (Reference 8); topographic maps at a scale of 1:24,000, with contour intervals of 10 feet (Reference 12) and 20 feet (Reference 13), and at a scale of 1:62,500, with a contour interval of 40 feet (Reference 14); visual approximations based on estimated runoff per acre; topography; and field surveys.

In accordance with FEMA guidelines, areas of approximate flooding less than 200 feet wide were determined to be areas of minimal flood hazard and were not delineated.

Approximate flood boundaries in some portions of the study area were taken from the Flood Hazard Boundary Map (FHBM) (Reference 15).

Flood boundaries for the 100- and 500-year floods are shown on the FBFM (Exhibit 2). In cases where the 100- and 500-year flood boundaries are close together, only the 100-year flood boundary has been shown. Small areas within the flood boundaries may lie above the flood elevations and are not subject to flooding; because of limitations of the map scale, such areas are not shown.

4.2 Floodways

Encroachment on floodplains, such as artificial fill, reduces flood-carrying capacity, increases the flood heights of streams, and increases flood hazards in areas beyond the encroachment itself. One aspect of floodplain management involves balancing the economic gain

from floodplain development against the resulting increase in flood hazard. For purposes of the NFIP, the concept of a floodway is used as a tool to assist local communities in this aspect of floodplain management. Under this concept, the area of the 100-year flood is divided into a floodway and a floodway fringe. The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment in order that the 100-year flood may be carried without substantial increases in flood heights. Minimum standards of FEMA limit such increases in flood heights to 1.0 foot, provided that hazardous velocities are not produced. The floodways in this report are presented to local agencies as minimum standards that can be adopted or that can be used as a basis for additional studies.

The floodways presented in this study were computed on the basis of equal-conveyance reduction from each side of the floodplain, except for the Little Colorado River at Holbrook, where the USACE levee was used as the encroachment line on the north side of the Little Colorado River. This was compatible with the developmental interests of Navajo County and the City of Holbrook. The results of these computations were tabulated at selected cross sections for each stream segment for which a floodway was computed (Table 3).

As shown on the FBFM (Exhibit 2), the floodway widths were determined at cross sections; between cross sections, the boundaries were interpolated. In cases where the boundaries of the floodway and the 100-year flood are either close together or collinear, only the floodway boundary was shown.

An initial attempt to establish a floodway on the basis of a 1.0-foot increase in 100-year WSEL criteria resulted in extreme backwater problems with the excessive encroachments. It was, therefore, necessary to limit the specified WSEL increases to less than 1.0 foot.

The area between the floodway and the boundary of the 100-year flood is termed the floodway fringe. The floodway fringe thus encompasses the portion of the floodplain that could be completely obstructed without increasing the WSEL of the 100-year flood more than 1.0 foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to floodplain development are shown in Figure 8.

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE [1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD)			
Black Canyon Wash								
A	15.89	448	1,713	7.7	6,411.3	6,411.3	6,411.4	0.1
B	16.03	414	1,251	10.6	6,414.6	6,414.6	6,414.6	0.0
C	16.17	351	1,858	7.1	6,418.4	6,418.4	6,418.5	0.1
D	16.30	214	1,274	10.4	6,419.5	6,419.5	6,419.9	0.4
E	16.46	289	1,775	7.5	6,423.3	6,423.3	6,423.3	0.0
F	16.54	281	1,613	8.2	6,424.1	6,424.1	6,424.1	0.0
G	16.71	249	772	10.1	6,429.4	6,429.4	6,429.4	0.0
H	16.83	229	762	10.3	6,435.8	6,435.8	6,435.8	0.0
I	16.93	140	958	8.2	6,438.8	6,438.8	6,438.8	0.0
J	17.01	120	607	12.9	6,442.3	6,442.3	6,442.3	0.0
K	17.08	215	1,133	6.9	6,444.5	6,444.5	6,445.0	0.5
L	17.22	216	773	10.1	6,448.7	6,448.7	6,448.7	0.0
M	17.33	154	680	11.5	6,453.6	6,453.6	6,453.6	0.0
N	17.43	152	647	12.1	6,457.5	6,457.5	6,457.5	0.0
O	17.51	245	810	9.7	6,461.1	6,461.1	6,461.1	0.0
P	17.61	116	602	13.0	6,463.6	6,463.6	6,463.6	0.0
Q	17.71	307	1,265	6.2	6,468.1	6,468.1	6,468.1	0.0
R	17.84	185	752	10.4	6,473.5	6,473.5	6,473.5	0.0
S	17.96	293	950	8.2	6,477.5	6,477.5	6,477.5	0.0
T	18.07	172	686	11.4	6,480.3	6,480.3	6,480.3	0.0
U	18.16	122	602	13.0	6,483.5	6,483.5	6,483.5	0.0
V	18.24	321	1,020	7.7	6,487.5	6,487.5	6,487.5	0.0
W	18.31	293	1,027	7.6	6,488.9	6,488.9	6,488.9	0.0

[1]Miles Above Confluence With Brookbank Canyon

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

NAVAJO COUNTY, AZ
(UNINCORPORATED AREAS)

FLOODWAY DATA

BLACK CANYON WASH

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD)			
Buckskin Wash								
A	0.14	60	440	15.4	6,430.3	6,430.3	6,430.3	0.0
B	0.19	202	848	8.0	6,434.1	6,434.1	6,434.1	0.0
C	0.28	257	735	9.2	6,436.2	6,436.2	6,436.2	0.0
D	0.38	231	650	10.4	6,441.3	6,441.3	6,441.3	0.0
E	0.51	125	690	9.8	6,443.9	6,443.9	6,444.4	0.5
F	0.63	187	715	9.5	6,447.8	6,447.8	6,447.8	0.0
G	0.73	191	630	10.7	6,450.7	6,450.7	6,450.7	0.0
H	0.83	261	994	6.8	6,454.5	6,454.5	6,454.5	0.0
I	0.98	370	801	8.4	6,459.6	6,459.6	6,459.6	0.0
J	1.09	338	956	7.1	6,464.3	6,464.3	6,464.3	0.0
K	1.20	210	663	10.2	6,469.0	6,469.0	6,469.0	0.0
L	1.31	195	893	7.6	7,473.2	7,473.2	6,473.2	0.0
M	1.42	177	630	10.7	6,477.7	6,477.7	6,477.7	0.0
N	1.54	365	1,346	5.0	6,481.2	6,481.2	6,481.2	0.0
O	1.62	271	711	9.2	6,483.5	6,483.5	6,483.5	0.0
P	1.70	367	1,051	6.2	6,488.3	6,488.3	6,488.3	0.0
Q	1.77	183	623	10.5	6,491.7	6,491.7	6,491.4	0.0
R	1.85	335	1,298	5.0	6,495.2	6,495.2	6,495.5	0.3
S	1.93	207	647	10.1	6,497.2	6,497.2	6,497.3	0.1
T	1.99	176	826	7.9	6,500.2	6,500.2	6,500.8	0.6
U	2.13	320	1,262	5.2	6,503.9	6,503.9	6,504.5	0.6
V	2.20	300	852	7.7	6,505.9	6,505.9	6,506.1	0.2
W	2.27	394	1,189	5.5	6,509.6	6,509.6	6,509.6	0.0
X	2.36	234	751	8.7	6,512.3	6,512.3	6,512.4	0.1
Y	2.41	375	1,837	3.6	6,513.8	6,513.8	6,514.3	0.5
Z	2.49	301	732	8.9	6,515.1	6,515.1	6,515.1	0.0

[1]Miles Above Confluence With Black Canyon Wash

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

NAVAJO COUNTY, AZ
(UNINCORPORATED AREAS)

FLOODWAY DATA

BUCKSKIN WASH

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD)			
Buckskin Wash (Cont'd)								
AA	2.57	159	704	9.3	6,520.3	6,520.3	6,520.5	0.2
AB	2.66	158	726	9.0	6,524.0	6,524.0	6,524.4	0.4
AC	2.74	125	666	9.8	6,527.5	6,527.5	6,527.6	0.1
AD	2.82	211	1,014	6.4	6,530.3	6,530.3	6,531.1	0.8
AE	2.95	291	1,041	6.3	6,534.3	6,534.3	6,534.1	0.0
AF	3.04	230	852	7.7	6,536.5	6,536.5	6,536.8	0.3
AG	3.14	275	915	7.1	6,540.2	6,540.2	6,541.1	0.9
AH	3.22	192	976	6.7	6,544.9	6,544.9	6,545.2	0.3
AI	3.35	249	1,146	5.7	6,548.7	6,548.7	6,548.9	0.2
AJ	3.43	262	1,073	6.1	6,551.1	6,551.1	6,551.2	0.1

[1]Miles Above Confluence With Black Canyon Wash

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD)			
Oklahoma Flat Draw								
A	16,520	99	551	9.5	6,489.3	6,489.3	6,490.0	0.7
B	17,050	147	920	5.7	6,493.6	6,493.6	6,494.6	1.0
C	17,470	195	570	9.2	6,496.6	6,496.6	6,496.7	0.1
D	18,000	214	1,219	4.3	6,500.5	6,500.5	6,500.9	0.4
E	18,530	160	800	6.6	6,502.0	6,502.0	6,502.8	0.8
F	19,060	170	740	7.1	6,504.7	6,504.7	6,505.7	1.0
G	19,590	161	668	7.9	6,509.8	6,509.8	6,510.2	0.4
H	20,110	258	1,094	4.8	6,513.8	6,513.8	6,514.7	0.9
I	20,640	285	977	5.4	6,516.9	6,516.9	6,517.5	0.6
J	21,170	128	621	8.4	6,521.3	6,521.3	6,521.9	0.6
K	21,700	321	1,387	3.8	6,525.4	6,525.4	6,526.2	0.8
L	22,230	138	651	8.1	6,528.9	6,528.9	6,529.2	0.3
M	22,750	133	738	7.1	6,532.8	6,532.8	6,533.7	0.9
N	23,280	155	687	7.6	6,537.1	6,537.1	6,537.7	0.6
O	23,810	210	1,089	4.8	6,541.1	6,541.1	6,542.0	0.9
P	24,340	166	615	8.5	6,545.1	6,545.1	6,545.6	0.5
Q	24,760	386	1,404	3.7	6,548.4	6,548.4	6,549.3	0.9
R	25,180	152	516	10.2	6,549.8	6,549.8	6,550.0	0.2
S	25,710	286	1,249	4.2	6,554.0	6,554.0	6,554.9	0.9
T	26,240	140	536	9.8	6,556.6	6,556.6	6,557.0	0.4
U	26,710	310	1,242	3.9	6,560.2	6,560.2	6,561.1	0.9
V	27,190	405	937	5.2	6,562.7	6,562.7	6,563.1	0.4
W	27,720	243	724	6.7	6,567.9	6,567.9	6,568.3	0.4
X	28,240	395	1,096	4.4	6,571.8	6,571.8	6,572.8	1.0
Y	28,830	374	725	6.7	6,577.1	6,577.1	6,577.8	0.7
Z	29,350	420	1,027	4.7	6,582.9	6,582.9	6,583.8	0.9

[1]Feet Above Confluence With Pierce Wash

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

NAVAJO COUNTY, AZ
(UNINCORPORATED AREAS)

FLOODWAY DATA

OKLAHOMA FLAT DRAW

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD)			
Oklahoma Flat Draw								
AA	29,880	843	1,828	2.7	6,587.9	6,587.9	6,587.9	0.0
AB	30,090	768	1,534	3.2	6,589.5	6,589.5	6,589.5	0.0
AC	30,410	161	359	8.1	6,591.1	6,591.1	6,591.1	0.0
AD	30,460	334	662	4.4	6,596.3	6,596.3	6,596.7	0.4
AE	30,780	81	490	6.0	6,596.4	6,596.4	6,597.1	0.7
AF	31,150	82	464	6.3	6,600.0	6,600.0	6,600.0	0.0
AG	31,360	74	267	10.9	6,602.1	6,602.1	6,602.2	0.1

[1]Feet Above Confluence With Pierce Wash

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

NAVAJO COUNTY, AZ
(UNINCORPORATED AREAS)

FLOODWAY DATA

OKLAHOMA FLAT DRAW

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD)			
Pinedale Wash								
A	1.18[1]	142	284	8.0	6,396.5	6,396.5	6,396.5	0.0
B	1.28[1]	212	393	5.8	6,403.9	6,403.9	6,404.0	0.1
C	1.34[1]	83	240	9.5	6,408.3	6,408.3	6,408.7	0.4
D	1.44[1]	100	309	7.4	6,415.1	6,415.1	6,415.6	0.5
E	1.54[1]	156	289	7.9	6,423.1	6,423.1	6,423.1	0.0
F	1.63[1]	86	248	9.1	6,430.9	6,430.9	6,431.0	0.1
G	1.74[1]	100	289	7.8	6,438.8	6,438.8	6,438.8	0.0
H	1.84[1]	75	229	9.9	6,445.5	6,445.5	6,445.5	0.0
I	1.93[1]	102	304	7.5	6,452.2	6,452.2	6,452.6	0.4
J	2.05[1]	59	213	10.6	6,460.8	6,460.8	6,461.0	0.2
K	2.14[1]	71	296	7.7	6,465.7	6,465.7	6,466.6	0.9
Porter Canyon Draw								
A	0.45[2]	1,465	3,867	3.0	5,061.5	5,061.5	5,062.2	0.7
B	0.55[2]	1,020	2,547	4.6	5,064.5	5,064.5	5,065.0	0.5
C	0.67[2]	670	1,849	6.3	5,068.6	5,068.6	5,069.1	0.5
D	0.712[2]	545	1,832	6.4	5,072.5	5,072.5	5,072.9	0.4
E	0.75[2]	449	1,646	7.1	5,074.6	5,074.6	5,075.4	0.8
F	0.85[2]	353	1,704	6.8	5,077.7	5,077.7	5,078.6	0.9
G	0.95[2]	224	1,274	9.1	5,081.5	5,081.5	5,082.4	0.9
H	1.05[2]	196	1,176	9.9	5,084.7	5,084.7	5,084.7	0.0
I	1.15[2]	216	1,214	9.6	5,087.9	5,087.9	5,088.3	0.4
J	1.22[2]	211	1,181	9.9	5,090.5	5,090.5	5,090.9	0.4

[1]Miles Above Confluence With Mortensen Wash [2]Miles Above Confluence With Little Colorado River

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

NAVAJO COUNTY, AZ
(UNINCORPORATED AREAS)

FLOODWAY DATA

PINEDALE WASH-PORTER CANYON DRAW

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD)			
Ruby Wash								
A	-4,870	1,772	881	4.8	4,828.4	4,824.5	4,825.3[2]	0.8
B	-4,340	2,112	2,546	1.7	4,828.4	4,826.5	4,827.3[2]	0.8
C	-3,810	1,400	2,436	1.7	4,828.4	4,826.9	4,827.7[2]	0.8
D	-3,280	1,647	2,234	1.9	4,828.4	4,827.3	4,828.2[2]	0.9
E	-2,750	2,035	2,411	1.7	4,828.4	4,827.7	4,828.7[2]	1.0
F	-2,230	1,786	2,224	1.9	4,828.4	4,828.2	4,829.2[2]	1.0
G	-1,690	1,700	2,740	1.5	4,828.7	4,828.7	4,829.7	1.0
H	-1,160	1,430	2,739	1.5	4,829.0	4,829.0	4,830.0	1.0
I	-680	1,829	3,588	1.2	4,829.2	4,829.2	4,830.2	1.0
J	-630	1,600	1,649	2.6	4,829.5	4,829.5	4,829.5	0.0
K	-30	1,900	2,973	1.4	4,829.9	4,829.9	4,830.5	0.6
L	410	1,548	5,851	0.7	4,831.1	4,831.1	4,832.1	1.0
M	970	1,550	5,353	0.8	4,831.2	4,831.2	4,832.2	1.0
N	1,510	1,395	5,305	0.8	4,831.2	4,831.2	4,832.2	1.0
O	2,060	1,415	4,756	0.9	4,831.3	4,831.3	4,832.3	1.0
P	2,580	1,055	3,583	1.2	4,831.3	4,831.3	4,832.3	1.0
Q	3,140	1,135	3,797	1.1	4,831.4	4,831.4	4,832.3	0.9
R	3,670	1,040	3,671	1.1	4,831.5	4,831.5	4,832.4	0.9
S	4,190	1,020	3,387	1.2	4,831.6	4,831.6	4,832.5	0.9
T	4,710	1,020	2,917	1.4	4,831.7	4,831.7	4,832.5	0.8
U	5,250	830	2,479	1.7	4,832.0	4,832.0	4,832.6	0.6
V	5,770	475	1,414	3.0	4,832.3	4,832.3	4,832.7	0.4
W	6,310	385	1,336	3.2	4,832.8	4,832.8	4,833.2	0.4
X	6,810	385	1,222	3.5	4,833.3	4,833.3	4,833.6	0.3
Y	7,330	390	763	2.9	4,833.7	4,833.7	4,834.0	0.3

[1]Feet Above North Park Drive
[2]Water-surface Elevation Computed Without Consideration of Backwater Effects

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

NAVAJO COUNTY, AZ
(UNINCORPORATED AREAS)

FLOODWAY DATA

RUBY WASH

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD)			
Show Low Creek								
A	395	285	2,172	6.6	6,351.0	6,351.0	6,351.1	0.1
B	926	285	2,049	7.0	6,351.7	6,351.7	6,351.8	0.1
C	1,454	139	1,008	14.3	6,351.7	6,351.7	6,351.7	0.0
D	2,004	235	2,441	5.9	6,355.6	6,355.6	6,355.6	0.0
E	2,588	630	4,325	3.3	6,356.1	6,356.1	6,356.4	0.3
F	3,116	723	3,760	3.8	6,356.3	6,356.3	6,356.7	0.4
G	3,659	470	2,182	6.6	6,356.6	6,356.6	6,357.1	0.5
H	4,188	105	876	16.5	6,360.2	6,360.2	6,360.2	0.0
I	4,680	150	1,356	10.6	6,365.9	6,365.9	6,366.4	0.5
J	5,209	150	985	14.6	6,370.6	6,370.6	6,370.6	0.0
K	5,726	140	953	15.1	6,378.5	6,378.5	6,378.5	0.0
L	6,269	105	879	16.4	6,386.3	6,386.3	6,386.3	0.0
M	6,769	113	901	16.0	6,393.6	6,393.6	6,393.6	0.0
N	7,292	89	829	17.4	6,399.8	6,399.8	6,399.9	0.1
O	7,810	100	859	16.8	6,406.8	6,406.8	6,406.8	0.0
P	8,317	148	1,070	13.5	6,414.0	6,414.0	6,414.0	0.0
Q	8,831	80	818	17.6	6,419.9	6,419.9	6,420.2	0.3
R	9,351	112	900	16.0	6,425.0	6,425.0	6,425.0	0.0
S	9,891	118	904	16.0	6,434.0	6,434.0	6,343.0	0.0
T	10,382	115	907	15.9	6,443.9	6,443.9	6,443.9	0.0
U	10,894	63	739	19.5	6,455.3	6,455.3	6,455.7	0.4
V	11,434	88	824	17.5	6,470.1	6,470.1	6,470.1	0.0
W	11,937	75	780	18.5	6,481.7	6,481.7	6,481.7	0.0
X	12,455	88	823	17.5	6,488.3	6,488.3	6,488.3	0.0
Y	12,977	88	822	17.5	6,497.3	6,497.3	6,497.3	0.0
Z	13,498	105	963	15.0	6,501.8	6,501.8	6,501.8	0.0

[1]Feet Above South Corporate Limits of the City of Show Low

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

NAVAJO COUNTY, AZ
(UNINCORPORATED AREAS)

FLOODWAY DATA

SHOW LOW CREEK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD)			
Show Low Creek								
AA	14,012	128	1,033	14.0	6,506.3	6,506.3	6,506.3	0.0
AB	14,535	139	1,057	13.6	6,509.8	6,509.8	6,510.7	0.9
AC	14,785	118	914	15.8	6,512.0	6,512.0	6,512.1	0.1
AD	19,215	166	964	13.8	6,556.5	6,556.5	6,556.5	0.0
AE	19,739	306	1,178	11.3	6,569.8	6,569.8	6,569.8	0.0
AF	20,160	222	1,067	12.5	6,576.3	6,576.3	6,576.3	0.0
AG	27,794	432	4,891	3.5	6,577.3	6,577.3	6,577.3	0.0
AH	28,303	118	1,164	14.5	6,577.3	6,577.3	6,577.3	0.0
AI	28,836	107	1,012	16.7	6,582.2	6,582.2	6,582.4	0.2
AJ	29,049	132	1,055	16.0	6,586.4	6,586.4	6,586.8	0.4
AK	29,304	114	998	16.9	6,589.1	6,589.1	6,589.1	0.0
AL	29,898	162	1,121	15.1	6,594.2	6,594.2	6,594.4	0.2
AM	30,433	149	1,092	15.5	6,599.3	6,599.3	6,599.3	0.0
AN	30,946	104	967	17.5	6,607.4	6,607.4	6,607.4	0.0

[1]Feet above South Corporate Limits of the City of Show Low

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

NAVAJO COUNTY, AZ
(UNINCORPORATED AREAS)

FLOODWAY DATA

SHOW LOW CREEK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD)			
Lower Silver Creek S-Z[2]								
AA	29.04	260/100[3]	942	14.2	5,639.0	5,639.0	5,639.1	0.1
AB	29.14	210/50[3]	1,142	10.8	5,641.0	5,641.0	5,641.9	0.9
AC	29.24	500/280[3]	3,031	5.2	5,642.8	5,642.8	5,643.8	1.0
AD	29.33	200/140[3]	1,378	7.0	5,643.1	5,643.1	5,643.8	0.7
AE	29.41	155	1,101	8.8	5,643.4	5,643.4	5,644.2	0.8
AF	29.51	152	943	11.5	5,644.8	5,644.8	5,645.1	0.3
AG	29.59	303	2,001	7.5	5,646.7	5,646.7	5,647.5	0.8
AH	29.71	467	2,311	8.7	5,647.3	5,647.3	5,648.2	0.9
AI	29.80	337	1,752	9.3	5,647.6	5,647.6	5,648.5	0.9
AJ	29.87	500	1,881	11.0	5,648.3	5,648.3	5,648.9	0.6
AK	29.95	147	901	15.8	5,649.3	5,649.3	5,649.4	0.1
AL	30.04	294	2,383	6.8	5,651.3	5,651.3	5,652.2	0.9
AM	30.12	463	3,143	6.0	5,651.7	5,651.7	5,652.6	0.9
AN	30.21	505	2,737	6.6	5,651.8	5,651.8	5,652.8	1.0
AO	30.31	596	3,257	6.1	5,652.2	5,652.2	5,653.1	0.9
AP	30.41	434	2,147	8.3	5,652.3	5,652.3	5,653.2	0.9
AQ	30.54	195	1,203	13.4	5,653.0	5,653.0	5,653.7	0.7
AR	30.60	245	1,568	11.7	5,654.1	5,654.1	5,655.1	1.0
AS	30.71	452	3,118	5.9	5,655.5	5,655.5	5,656.4	0.9
AT	30.81	400	2,237	8.9	5,655.6	5,655.6	5,656.4	0.8
AU	30.90	217	1,512	9.9	5,656.2	5,656.2	5,656.8	0.6
AV	31.01	197	1,464	10.7	5,656.8	5,656.8	5,657.5	0.7
AW	31.11	275	1,450	11.0	5,657.6	5,657.6	5,658.4	0.8
AX	31.20	577	497	19.4	5,659.1	5,659.1	5,659.9	0.8

[1]Miles Above Confluence With Little Colorado River [2]Entirely Outside County Limits [3]Total Width/Width Within County Limits

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

NAVAJO COUNTY, AZ
(UNINCORPORATED AREAS)

FLOODWAY DATA

LOWER SILVER CREEK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD)			
Silver Creek								
AY	31.30	492	4,276	3.7	5,662.6	5,662.6	5,662.8	0.2
AZ	31.42	496	3,681	4.3	5,662.7	5,662.7	5,662.9	0.2
BA	31.53	398	2,770	5.8	5,662.8	5,662.8	5,663.1	0.3
BB	31.63	306	2,787	5.7	5,662.9	5,662.9	5,663.2	0.3
BC	31.75	672	6,193	2.6	5,663.5	5,663.5	5,663.9	0.4
BD	31.88	402	3,452	4.6	5,663.4	5,663.4	5,663.7	0.3
BE	31.96	422	4,090	3.9	5,663.8	5,663.8	5,664.2	0.4
BF	32.04	345	3,630	4.4	5,663.9	5,663.9	5,664.3	0.4
BG	32.20	390	3,827	4.2	5,664.1	5,664.1	5,664.5	0.4
BH	32.31	265	2,103	7.6	5,664.2	5,664.2	5,664.6	0.4
BI	32.40	472	2,606	6.1	5,665.1	5,665.1	5,665.6	0.5
BJ	32.53	461	2,174	7.4	5,666.1	5,666.1	5,666.7	0.6
BK	32.64	394	2,710	5.9	5,667.8	5,667.8	5,668.1	0.3
BL	32.71	340	2,049	7.8	5,668.1	5,668.1	5,668.4	0.3
BM	32.85	409	1,927	8.3	5,669.3	5,669.3	5,670.0	0.7
BN	32.96	554	3,970	4.0	5,671.7	5,671.7	5,671.8	0.1
BO	33.07	443	3,216	5.0	5,671.8	5,671.8	5,671.9	0.1
BP	33.17	488	3,589	4.5	5,672.2	5,672.2	5,672.4	0.2
BQ	33.21	425	1,832	8.7	5,672.3	5,672.3	5,672.3	0.0
BR	33.28	441	2,157	7.4	5,673.5	5,673.5	5,673.9	0.4
BS	33.39	550	3,564	4.5	5,675.5	5,675.5	5,675.6	0.1
BT	33.48	510	2,135	7.5	5,676.1	5,676.1	5,676.1	0.0
BU	33.54	540	1,983	8.1	5,679.0	5,679.0	5,679.1	0.1
BV	33.64	517	1,996	8.0	5,682.5	5,682.5	5,682.5	0.0
BW	33.72	380	1,822	8.8	5,689.9	5,689.9	5,689.9	0.0
BX	33.8	316	1,591	10.1	5,698.9	5,698.9	5,698.9	0.0
BY	33.89	372	1,577	10.1	5,712.8	5,712.8	5,712.8	0.0
BZ	33.96	141	1,033	15.5	5,712.2	5,712.2	5,712.2	0.0
CA	34.04	144	1,070	14.9	5,719.8	5,719.8	5,719.8	0.0
CB	34.12	138	1,038	15.4	5,723.4	5,723.4	5,723.4	0.0
CC	34.2	129	1,058	15.1	5,725.4	5,725.4	5,725.4	0.0

[1]Miles Above Confluence With Little Colorado River

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

NAVAJO COUNTY, AZ
(UNINCORPORATED AREAS)

FLOODWAY DATA

SILVER CREEK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD)			
Upper Silver Creek A-S[2]								
T	41.83	189	2,078	6.7	6,093.0	6,093.0	6,093.0	0.0
U	42.05	182	1,769	8.2	6,094.2	6,094.2	6,094.4	0.2
V	42.28	204	2,611	4.7	6,103.9	6,103.9	6,103.9	0.0
W	42.37	181	2,441	5.0	6,104.6	6,104.6	6,104.9	0.3
X	42.45	173	2,433	5.1	6,105.3	6,105.3	6,105.8	0.5
Y	42.69	385	3,736	3.7	6,106.8	6,106.8	6,107.6	0.8

[1]Miles Above Confluence With Little Colorado River [2]No Floodway Determined

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

NAVAJO COUNTY, AZ
(UNINCORPORATED AREAS)

FLOODWAY DATA

UPPER SILVER CREEK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD)			
Town Wash								
A	7.64[1]	250	281	5.9	6,264.2	6,264.2	6,264.7	0.5
B	7.74[1]	93	199	8.3	6,271.0	6,271.0	6,271.4	0.4
C	7.78[1]	146	248	6.6	6,274.7	6,274.7	6,275.5	0.8
D	7.86[1]	111	277	5.9	6,278.5	6,278.5	6,278.8	0.3
E	7.92[1]	113	238	6.9	6,283.3	6,283.3	6,283.8	0.5
F	7.99[1]	45	175	9.4	6,286.7	6,286.7	6,286.7	0.0
G	8.05[1]	92	224	7.4	6,292.4	6,292.4	6,292.9	0.5
H	8.12[1]	160	304	5.4	6,295.4	6,295.4	6,296.2	0.8
I	8.26[1]	67	177	9.3	6,303.7	6,303.7	6,303.7	0.0
J	8.39[1]	231	265	6.2	6,315.0	6,315.0	6,315.9	0.9
K	8.52[1]	260	277	5.9	6,324.9	6,324.9	6,324.9	0.0
Walnut Gulch Creek								
A	2.29[2]	152	503	3.2	6,901.0	6,901.0	6,901.7	0.7
B	2.44[2]	88	191	8.4	6,905.0	6,905.0	6,905.9	0.9
C	2.54[2]	80	240	6.7	6,911.8	6,911.8	6,912.0	0.2
D	2.62[2]	140	353	4.5	6,914.1	6,914.1	6,914.4	0.3
E	2.68[2]	246	589	2.7	6,914.8	6,914.8	6,915.4	0.6
F	2.85[2]	95	195	8.2	6,922.4	6,922.4	6,922.6	0.2
G	2.95[2]	470	362	4.4	6,932.7	6,932.7	6,932.8	0.1
H	3.09[2]	151	388	4.1	6,936.8	6,936.8	6,937.3	0.5
I	3.21[2]	80	184	8.7	6,944.7	6,944.7	6,945.1	0.4
J	3.33[2]	70	176	9.1	6,955.9	6,955.9	6,956.2	0.3
K	3.45[2]	55	164	9.8	6,970.9	6,970.9	6,970.9	0.0

[1]Miles Above Confluence With Cottonwood Wash [2]Miles Above Rainbow Lake

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

NAVAJO COUNTY, AZ
(UNINCORPORATED AREAS)

FLOODWAY DATA

TOWN WASH-WALNUT GULCH CREEK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD)			
Whiting Creek								
A	0.71	233	148	5.5	5,097.1	5,097.1	5,097.1	0.0
B	0.85	38	110	7.4	5,105.1	5,105.1	5,105.1	0.0
C	0.95	44	96	8.5	5,112.7	5,112.7	5,112.7	0.0
D	1.06	59	113	7.2	5,123.9	5,123.9	5,123.9	0.0
E	1.14	50	98	8.3	5,128.9	5,128.9	5,128.9	0.0
F	1.24	58	123	6.6	5,134.9	5,134.9	5,134.9	0.0
G	1.34	113	142	5.7	5,146.5	5,146.5	5,146.5	0.0
H	1.43	156	171	4.8	5,153.0	5,153.0	5,153.0	0.0

[1]Miles Above Confluence With Little Colorado River

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

NAVAJO COUNTY, AZ
(UNINCORPORATED AREAS)

FLOODWAY DATA

WHITING CREEK

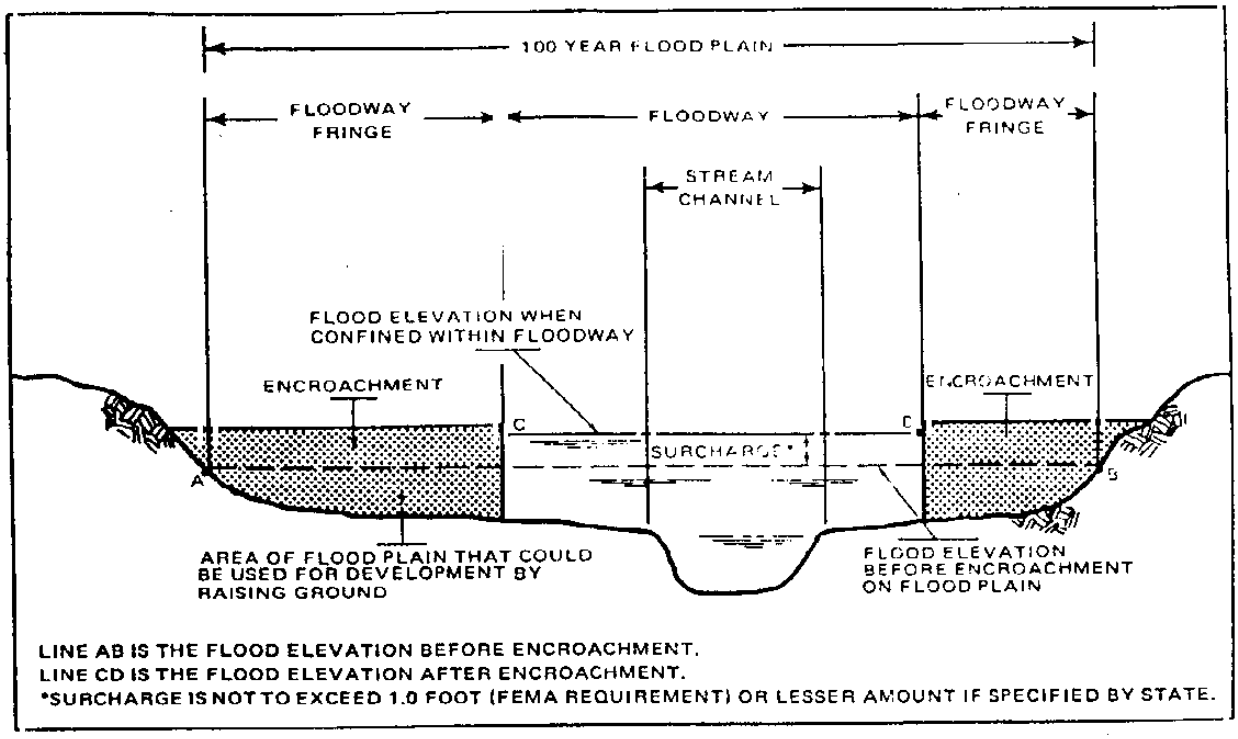

Figure 8. Floodway Schematic

5.0 INSURANCE APPLICATION

In order to establish actuarial insurance rates, FEMA has developed a process to transform the data from the engineering study into flood insurance criteria. This process includes the determination of reaches, Flood Hazard Factors (FHFs), and flood insurance zone designations for each flooding source studied in detail affecting Navajo County.

5.1 Reach Determinations

Reaches are defined as lengths of watercourses having relatively the same flood hazard, based on the average weighted difference in WSELs between the 10- and 100-year floods. This difference does not have a variation greater than that indicated in the following table for more than 20 percent of the reach:

Average Difference Between 10- and 100-Year Floods	Variation
Less than 2 feet	0.5 foot
2 to 7 feet	1.0 foot
7.1 to 12 feet	2.0 feet
More than 12 feet	3.0 feet

The locations of the reaches determined for the flooding sources of Navajo County are shown on the Flood Profiles (Exhibit 1) and summarized in Table 4.

5.2 Flood Hazard Factors

The FHF is the FEMA device used to correlate flood information with insurance rate tables. Correlations between property damage from floods and the FHF are used to set actuarial insurance premium rate tables based on FHFs from 005 to 200.

The FHF for a reach is the average weighted difference between the 10- and 100-year flood WSELs expressed to the nearest 0.5 foot, and shown as a three-digit code. For example, if the difference between WSELs of the 10- and 100-year floods is 0.7 foot, the FHF is 005; if the difference is 1.4 feet, the FHF is 015; if the difference is 5.0 feet, the FHF is 050. When the difference between the 10- and 100-year WSELs is greater than 10.0 feet, accuracy for the FHF is to the nearest foot.

5.3 Flood Insurance Zones

After the determination of reaches and their respective FHFs, the entire unincorporated area of Navajo County was divided into zones, each having a specific flood potential or hazard. Each zone was assigned one of the following flood insurance zone designations:

Zone A:	Special Flood Hazard Areas (SFHAs) inundated by the 100-year flood, determined by approximate methods; no Base Flood Elevations (BFEs) shown or FHFs determined.
Zone AH:	SFHAs inundated by types of 100-year shallow flooding where depths are between 1.0 and 3.0 feet; BFEs are shown, but no FHFs are determined.
Zones A2-A6, A8-A10, A15, and A17:	SFHAs inundated by the 100-year flood, determined by detailed methods; BFEs shown, and zones subdivided according to FHFs.
Zone B:	Areas between the SFHAs and the limits of the 500-year flood, including areas of the 500-year floodplain that are protected from the 100-year flood by dike, levee, or other water-control structure; also areas subject to certain types of 100-year shallow flooding where depths are less than 1.0 foot; and areas subject to 100-year flooding from sources with drainage areas less than 1 square mile. Zone B is not subdivided.
Zone C:	Areas of minimal flooding.

The flood elevation differences, FHFs, flood insurance zones, and BFEs for each flooding source studied in detail in the community are summarized in Table 4.

5.4 Flood Insurance Rate Map Description

The Flood Insurance Rate Map (FIRM) for Navajo County is, for insurance purposes, the principal result of the FIS. This map (published separately) contains the official delineation of flood insurance zones and BFE lines. BFE lines show the locations of the expected whole-foot WSELs of the base (100-year) flood. This map is developed in accordance with the latest flood insurance map preparation guidelines published by FEMA.

6.0 OTHER STUDIES

Other studies found for Navajo County include the USACE Floodplain Information report entitled Little Colorado River, Vicinity of Winslow, Navajo County, Arizona (Reference 4), and the USACE Information Brochure entitled Alternative Proposals for Flood Control and Allied Purposes, Little Colorado River, Holbrook, Arizona (Reference 16)

The USACE also completed a preliminary hydrologic study of the Little Colorado River at Holbrook (Reference 3). Flood elevation information from that report was compared to the results of this FIS. The profiles agreed to within 0.5 foot. The USACE report was prepared primarily to evaluate economic losses resulting from high-magnitude flood events and was not fully compatible with the requirements of the NFIP. Therefore, that information was not used in constructing profiles for this study.

FISs were also prepared for the incorporated areas of the Cities of Winslow, Holbrook, Show Low, and the Towns of Taylor and Snowflake (References 17, 18, 19, 20, and 21, respectively) and the adjacent unincorporated areas of Graham County, Apache County, and Coconino County (References 22, 23, and 24, respectively). The results of those studies will be in general agreement with this analysis.

Flood boundary delineations for this study supersede the FHBM (Reference 15).

This study is authoritative for the purposes of the NFIP; data presented herein either supersede or are compatible with all previous determinations.

7.0 LOCATION OF DATA

Information concerning the pertinent data used in the preparation of this study can be obtained by contacting FEMA, Region IX, Federal Insurance and Mitigation Administration, 1111 Broadway Street, Suite 1200, Oakland, California 94607-4052.

8.0 BIBLIOGRAPHY AND REFERENCES

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9.0 REVISION DESCRIPTIONS

This section has been added to provide information regarding significant revisions made since the original FIS was printed. Future revisions may be made that do not result in the republishing of the FIS report. To assure that any user is aware of all revisions, it is advisable to contact the community repository of flood hazard data located at the Engineering Department, 100 East Carter Drive, Holbrook, Arizona 86025.

9.1 First Revision

This study was revised on August 16, 1988, to incorporate detailed flooding information for Rainbow Lake, which was previously studied by approximate methods. In addition, the Town of Pinetop-Lakeside was incorporated on July 24, 1984, and is now shown as an area not included on the Navajo County FIRM. An FIS and FIRM were prepared for the town and became effective on February 9, 1987. Walnut Creek Gulch, a portion of Billy Creek, and a portion of Rainbow Lake, which are within the Town

of Pinetop-Lakeside, were removed from the Navajo County FIRM. However, information concerning the Town of Pinetop-Lakeside and Walnut Gulch Creek were not deleted from the Navajo County FIS.

The flooding information for Rainbow Lake is based on data contained in a report entitled Final Drainage Report for the Shores at Rainbow Lake, Lakeside, Navajo County, Arizona prepared by Collar, Williams, and White Engineering, Inc., Phoenix, Arizona, in March 1986 and revised in April 1986. Based on this report, the 100- and 500-year flood elevations on Rainbow Lake are 6712.8 and 6714.0 feet NGVD, respectively.

The changes resulted in revisions to the Summary of Discharges table, Manning's "n" Values table, Floodway Data table, and Flood Insurance Zone Data table.

The FIS and FIRM for the Town of Pinetop-Lakeside also were revised to reflect these changes.

9.2 Second Revision

This FIS was revised on September 30, 1992, to incorporate detailed flooding information for the Little Colorado River, Ruby Wash, Show Low Creek, and Oklahoma Flat Draw.

Authority and Acknowledgements

The hydraulic analyses for this study were prepared by AGK Engineers, Inc., (AGK) the SC, for FEMA, under Contract No. EMW-89-C-02839. This work was completed in September 1990.

Coordination

On August 9, 1988, an initial CCO meeting was held with representatives of FEMA, Navajo County, the Arizona Department of Water Resources (ADWR), the City of Show Low, and the SC.

As part of a data-collection site visit, a meeting with the staff of Navajo County, the Cities of Winslow and Show Low, and representatives of the SC was held on June 7, 1989.

On March 10, 1992, the results of the study were reviewed at the final CCO meeting. This meeting was attended by representatives of Navajo County, the Cities of Winslow and Show Low, the ADWR, FEMA, and the SC.

Scope of Study

For this restudy, riverine flooding of the following streams was studied by detailed methods:

Little Colorado River – From the Atchison, Topeka & Santa Fe Railroad (ATSFRR) bridge to the north section line of Sections 4 and 5, Township 19 North, Range 16 East;

Ruby Wash – From the ATSFRR bridge to the north section line of Township 19;

Show Low Creek – From immediately upstream of Show Low Lake to the southern corporate limit of the City of Show Low; and

Oklahoma Flat Draw – From State Highway 260 to the northern limits of the Pine Meadow Development.

The scope and methods of study were proposed to and agreed upon by representatives of FEMA and Navajo County.

Navajo County attempted to minimize the flooding problems along the Little Colorado River by constructing an earthen levee from the ATSFRR to approximately one-quarter mile north of McHood Drive near Ames Acres. This levee was overtopped and breached at several locations during a major flood in December 1978 (Reference 25). A new levee was constructed by Navajo County in 1989 with assistance from the ADWR. Rock riprap was placed along several short sections of the levee to protect the earthen embankment from erosion. Based on improvements completed in 1991, this levee was recognized as providing 100-year flood protection.

No flood-control measures exist or are planned for the portions of Show Low Creek and Oklahoma Flat Draw or for Ruby Wash within the unincorporated areas of Navajo County included in this study.

Hydrologic Analyses

The same discharges that were generated for the 1981 FIS (Reference 17) for the Little Colorado River at Winslow were used in this study because little change has been reported in the upstream watershed. The peak flows are presented in the Summary of Discharges table (Table 1).

Because of the absence of historical gaging data in the study area, the peak flows used for Ruby Wash in this study were obtained through hydrologic modeling. The hydrologic modeling was performed by using the HEC-1 computer program (Reference 26). The model utilizes a standard SCS Type II rainfall distribution for a 24-hour duration storm. Total rainfall depths were taken from the National Oceanic and Atmospheric Administration (NOAA) Atlas published for Arizona (Reference 27). Initial abstraction and losses were based upon the SCS curve number method. Curve numbers were estimated by weighted method on the basis of the soil information provided in Reference 2.

The runoff hydrographs were computed using the SCS unit hydrograph. The computed runoff hydrographs were then routed from various points in the watershed to the outlet by the kinematic wave method. Reservoir routing through fully characterized outflow structures such as culverts and weirs was performed by input of appropriate reservoir area-volume-elevation data into the model. Elevations and surface areas used in the model were based upon either the "as-built" documents obtained from the ADOT for the State Highway 87 and I-40, or the 1:4,800, 4-foot contour interval mapping flown for this project in 1989 (Reference 32). The 100-year peak flows at various locations in the study area are presented in the Summary of Discharges table (Table 1).

A USGS gaging station (Gaging Station 09-390500) is located on Show Low Creek. However, the station could not provide adequate peak flow information for this study because it is located approximately 6 miles upstream of the northern study limits.

Therefore, the peak flows used in this study were obtained through hydrologic modeling.

For Show Low Creek, the hydrologic modeling was performed by means of the HEC-1 computer program (Reference 26). The hydrographs from various watersheds were first routed to the location of Gaging Station 09-390500. The ordinates of the resulting hydrograph were then adjusted proportionally according to the ratio of the peak flow obtained from gaging records, by means of the log-Pearson Type III method, to the peak flow derived from modeling. Finally, the adjusted resulting hydrograph was used as the inflow hydrograph and was routed through Show Low Lake to the City of Show Low's southern corporate limit.

The SCS Type II rainfall distribution was used as the rainfall input of the model. Precipitation values for the 100-year, 24-hour storm were obtained from the NOAA Atlas for Arizona (Reference 27). The stage-storage-discharge curves for each retention structure in the watershed were adopted from a dam safety study report prepared for Jaques Dam (Reference 28). Spillway crest elevation values were used to set the initial storage volume for each of these structures. The runoff curve numbers were derived from the soil and vegetation cover information provided by the U.S. Forest Service (USFS) (References 29 and 30).

Gaging data were obtained from the USGS for Gaging Station 09-390500, which is located on Show Low Creek near Lakeside. This station has been in continuous service from May 1953 to the present. The annual peak flow for each of these years was recorded and tabulated. The log-Pearson Type III method was used to estimate the 100-year flood at the gaging station. The 100-year peak flows at various locations in the study area are presented in the Summary of Discharges table (Table 1).

For Oklahoma Flat Draw, in the absence of historical gaging data in the study area, the peak flows used in this study were obtained through hydrologic modeling. The hydrologic modeling was performed using the HEC-1 computer program (Reference 26). SCS Type II rainfall distribution was used as the rainfall input of the model. Precipitation values for the 100-year, 24-hour storm were obtained from the NOAA Atlas for Arizona (Reference 27). The runoff curve numbers were derived from the soil and vegetation cover information provided by the USFS (References 29 and 30).

The runoff hydrographs were computed by use of the SCS unit hydrograph. The computed runoff hydrographs were then routed from various points in the watershed to the outlet by the kinematic wave method. Reservoir routing through fully characterized outflow structures such as culverts and weirs was performed by input of appropriate reservoir area-volume-elevation data into the model.

Elevations and surface areas used in the model were based either upon the as-built documents obtained from the ADOT for the SH 260, or the 1:4,800, 4-foot contour interval mapping flown for this project in 1989 (Reference 31). The 160-year peak flows at various locations in the study area are presented in the Summary of Discharges table (Table 1).

Hydraulic Analysis

A hydraulic analysis for the 100-year flow along the Little Colorado River, Ruby Wash, Show Low Creek, and Oklahoma Flat Draw was performed by AGK. The mapping generated by Cooper Aerial of Phoenix, Inc., for the Little Colorado River (Reference 33), Ruby Wash (Reference 32), Show Low Creek (Reference 34), and Oklahoma Flat Draw (Reference 31) and the HEC-2 computer data generated by AGK were utilized to determine flood limits. Cross-section data for the backwater analyses of the Little Colorado River, Ruby Wash, Show Low Creek, and Oklahoma Flat Draw were determined by obtaining digitized cross sections from Cooper Aerial (References 31 through 34). WSELs for the 100-year flood were computed using the USACE HEC-2 Step Backwater Computer Program (Reference 35). The relevant WSEL from the 1981 FIS for the City of Winslow (Reference 17) was used as the starting WSEL for the Little Colorado River. Critical depth was used as the starting WSEL for Ruby Wash, Show Low Creek, and Oklahoma Flat Draw. Channel and overbank roughness (Manning's "n") factors used in the hydraulic computations were chosen by engineering judgment and based on field observation of the streams and floodplain areas.

The channel and overbank "n" values for the studied streams are shown in the table below:

	Channel	Overbank
Little Colorado River	0.023 to 0.077	0.035 to 0.125
Ruby Wash	0.025 to 0.035	0.030 to 0.080
Show Low Creek	0.020 to 0.040*	0.035 to 0.080
Oklahoma Flat Draw	0.025 to 0.050	0.050 to 0.080

*A value of 0.015 was used for the Manning's "n" of the concrete spillway of Jaques Dam.

Floodplain Boundaries

Floodplain boundaries were delineated in the detailed study reach of the Little Colorado River, Ruby Wash, Show Low Creek, and Oklahoma Flat Draw using topographic maps at a scale of 1:4,800, with a contour interval of 4 feet (References 31 through 34).

The floodway presented in this study was computed on the basis of equal conveyance reduction from each side of the floodplain. The floodway information is tabulated in the Floodway Data tables (Table 3). Floodways in areas of critical flow were determined so that a maximum rise of 1 foot occurred in the energy grade line.

Other Studies

The information for the study reach of the Little Colorado River supersedes the data presented in the previous FIS for the City of Winslow dated March 16, 1981 (Reference 17). In addition, the information for the study reach of Show Low Creek supersedes the data presented in the previous FIS for the unincorporated areas of Navajo County dated December 1, 1981 (Reference 38). The discharges used in the study of Show Low Creek flooding in Navajo County were computed using more recent data and therefore were higher than those used in the study of the lower reach through the City of Show Low.

Corrections to historical floodflow data for the Little Colorado River and to the hydrologic data for Silver Creek, as identified by the ADWR, have been added to Sections 2.3 and 3.0 of the original text with this update.

9.3 Third Revision

This study was revised on March 2, 1994, to incorporate the effects of new hydrologic and hydraulic analyses for Silver Creek.

The new hydrologic analyses were based on a study prepared by Kamineki-Hubbard Engineering, Inc. (KHE), that used the USACE HEC-1 computer model. The HEC-1 model included the effects of physical changes such as a dam, reservoir, and diversion structures that were constructed since the original FIS was completed. The structures included were Schoens Dam, the Millet Swale retention area, the Ortega Lake diversion system, and the Rocky Arroyo Wash diversion system into Long Lake.

The USACE HEC-2 computer model was utilized by KHE for the hydraulic analyses for Silver Creek. Although the revised hydraulic analyses included the 10-, 50-, 100-, and 500-year recurrence interval floods, only a revised 100-year floodplain and floodway were mapped. The effective 500-year floodplain boundaries were deleted in the revision area because revised boundaries based on the lower discharge were not developed. As a result of the hydrologic and hydraulic analyses, the peak discharges and BFEs decreased, and the 100-year floodway and floodplain boundaries changed.

The floodway and floodplain boundaries were delineated using topographic maps prepared by KHE at a scale of 1:4,800, with a contour interval of 2 feet.

The Summary of Discharges table, Floodway Data table, and Flood Profile panels for Silver Creek were revised as a result of these analyses. In addition, the Floodway Data Table and Flood Profile Panels 24P through 28P were revised to show the correct stream distances along Silver Creek.

As a result of this revision, the flooding shown between Cross Sections A and N on the previous FIRM no longer affects Navajo County. Therefore, part of the flooding shown on FIRM Panel 2206, part of Flood Profile Panel 22P, all of Flood Profile Panel 23P, and the Floodway Data Table from Cross

Section A to Cross Section N were deleted. The FIS and FIRM for the Towns of Snowflake and Taylor were also revised to reflect these changes.

9.4 Fourth Revision

This study was revised on June 5, 1997, to incorporate certain flooding information for Buckskin Wash. A reach of approximately 1.8 miles of Bucksin Wash, from RM 1.6 near the City of Heber to RM 3.4, was studied by detailed methods.

The hydrologic and hydraulic analyses for this study were prepared by Ensign & Buckley Consulting Engineers, the SC, for FEMA, under Contract EMW-90-C-9133. The work was completed in May 1993.

On February 25, 1992, an initial CCO meeting was held with representatives of Navajo County, the ADWR, FEMA, and the SC. The stream to be studied and the limits of study were identified at the meeting. Available mapping, previous studies, and other data were also discussed.

During the preparation of the study, telephone discussions were held between the SC and representatives of Navajo County and the State of Arizona.

The 100-year flood discharge was determined by the same method used for Buckskin Wash in the March 2, 1994, FIS (Reference 39). This method consisted of the regional regression formula, as developed by the USGS for the ADOT (Reference 5). The formula is as follows:

$$Q_{100} = 553A^{0.61} \times E^{-1.13} \times P^{0.915}$$

Where A = Area in square miles
E = Elevation factor in thousands of feet
P = Mean annual precipitation in inches

The area and elevation factors were determined from the USGS 7.5-Minute Series Topographic Maps for the area (Reference 14). The precipitation factor was estimated based on data used as input for the effective FIS dated March 2, 1994. The adopted study discharge is shown in Table 1, Summary of Discharges.

Channel and overbank cross sections were digitized from the aerial photogrametric survey conducted for this study (Reference 40)

WSELs were computed through the use of the USACE HEC-2 computer program (Reference 41)

Manning's "n" roughness values were estimated based on field observations and USACE and USGS criteria (References 36 and 42). The channel roughness values used varied between 0.03 and 0.05 for the natural earth channel. Overbank roughness values used ranged from 0.045 to 0.66.

The starting WSEL was set equal to the WSEL in the effective FIS at the upstream limit of study.

Supercritical flow conditions can occur in some channel reaches. Whenever supercritical flow occurs, the profiles were computed based on critical depths.

Floodplain and floodway boundaries were delineated using topographic maps at a scale of 1:2,400, with 2-foot contour intervals (Reference 43)

Where possible, the floodways presented in this study were computed for certain stream segments on the basis of equal conveyance reduction from each side of the floodplain. However, this could not be achieved at all times because of channel section configuration and high velocities and supercritical flows. As a result, floodway boundaries were based on encroachment analyses that limited both the maximum use in WSELs and energy grade line to 1 foot. Channel velocities exceeded potential erosive magnitudes of 7 to 11 feet per second along approximately half the length of stream studied. At several locations, the natural channel banks govern the floodway encroachment.

The study for this revision is in agreement with the March 2, 1994, FIS for Navajo County.

9.5 Fifth Revision

This study was revised on November 19, 2003, to incorporate new flood hazard information for Lower Silver Creek and Upper Silver Creek (formerly Silver Creek), Rocky Arroyo, White Mountain Lake, and Mexican Lake within Navajo County. The corporate limits were also updated for the county. The hydrologic analyses for all the revised reaches, with the exception of the Mexican/White Mountain Lake System, were adopted from the "Silver Creek Drainage Study" prepared for Navajo County by KHE (Reference 44). The hydrologic analysis for the Mexican/White Mountain Lake System incorporated a new rating curve and reservoir routing based on more accurate topographic data included in the HEC-1 model prepared by KHE. The hydraulic analyses were performed by Tetra Tech, Inc. (formerly ASL Consulting Engineers), for Navajo County under Project Order No. 2343-0001 (Reference 45). This study was completed in August 2000 and submitted to FEMA.

The peak discharges were established using the HEC-1 hydrologic computer model developed by the USACE (Reference 47).

Lower Silver Creek was restudied from approximately 21,300 feet upstream to approximately 22,000 feet upstream of Willow Lane and from approximately 23,100 feet upstream of Willow Lane to approximately 100 feet downstream of the confluence with Show Low Creek. BFEs, floodplain boundary delineations, and regulatory floodway boundary delineations increased and decreased along the revised reach.

Upper Silver Creek was studied from the confluence with White Mountain Lake to approximately 16,000 feet upstream. Bourdon Ranch Road, BFEs, and a regulatory floodway from approximately 10,900 feet upstream to approximately 16,000 feet upstream of the confluence with White Mountain Lake were added along the revised reach.

Mexican/White Mountain Lake Outlet was studied from the confluence of Mexican Lake Outlet and Silver Creek to approximately 8,000 feet upstream.

Rocky Arroyo was studied from White Mountain Lake to approximately 5,200 feet upstream, where it meets State land. BFEs were added, and the floodplain boundary delineations increased and decreased along the revised reach.

In addition, several FIRMs for Navajo County, Arizona, were converted to the Map Initiatives format. The following effective FIRM panels were converted to the Map Initiatives format: 2204 C, 2208 C, 2212 C, 2216 C, 2218 C, 2225 C, 2350 C, and 2375 C. In the Map Initiatives format, all BFEs, cross sections, and floodplain and floodway boundaries are shown on the FIRM. The flood insurance zone designations were changed to reflect the Map Initiatives format. Areas previously shown as numbered Zone A zones were revised to Zone AE, Zone B was revised to Zone X (shaded), and Zone C was revised to Zone X (unshaded). For flood insurance rating purposes, flood insurance zone designations are assigned to a community based on the results of the engineering analyses. These zones are as follows:

Zone AE

Zone AE is a flood insurance rate zone that corresponds to the 100-year floodplains that are determined in the FIS by detailed methods. Whole-foot BFEs derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone X

Zone X is the flood insurance rate zone that corresponds to areas outside the 500-year floodplain, areas within the 500-year floodplain, areas of 100-year flooding where average depths are less than 1 foot, areas of 100-year flooding where the contributing drainage area is less than 1 square mile, and areas protected from the 100-year flood by levees. No BFEs or depths are shown within this zone.

The Flood Insurance Zone Data Table was removed from the FIS report, and all zone designations and reach determinations were removed from all Flood Profile panels for the revised reaches of Lower and Upper Silver Creeks.

This revision also includes new FIRM Panels 2219 C, 2332 C, and 2351 C.

Drainage-basin delineations for Lower Silver Creek, Upper Silver Creek, and Rocky Arroyo Creek were made using 1"=200' scale topographic mapping with 2-foot contour intervals, provided by Navajo County, supplemented with USGS 7.5-minute quadrangle maps (References 48 and 49). Drainage-basin delineations for the Mexican/White Mountain Lake area were made using 1"=200' scale topographic mapping with 1-foot contour intervals (References 48 and 50).

The WSELs were computed using the USACE HEC-RAS computer program (Reference 46). The Lower Silver Creek starting WSEL was established from the 1994 FIS for the unincorporated areas of Navajo County. The Upper Silver Creek and Rocky Arroyo Creek starting WSELs were established from the static WSEL of White Mountain Lake. The starting WSEL for the Mexican/White Mountain Lake Outlet System was determined by using critical depth at the confluence of Lower Silver Creek and peak flow from the KHE report. Supercritical flow regimes were used in the HEC-RAS hydraulic models for Mexican/White Mountain Lake Outlet and Rocky Arroyo. However, critical depth was not mapped for these two revised reaches.

Channel and overbank cross sections were determined from Navajo County 200-foot, horizontal scale topographic mapping with 2-foot contour intervals (Reference 10); field measurements; and as-built drawings of channels and structures. Bridges and culverts were modeled according to their configurations.

Estimates for roughness coefficients (Manning's "n" values) were determined from site visits to the study area. The channel roughness values used for Lower Silver Creek varied between 0.027 and 0.045 for earthen channels and was 0.015 for concrete-lined sections of channels at bridge crossings. Overbank roughness values ranged from 0.04 to 0.05. The channel roughness values used for Upper Silver Creek varied between 0.025 and 0.11 for earthen channels. Overbank roughness values ranged from 0.06 to 0.125. The roughness coefficients used for the Mexican/White Mountain Lake Outlet varied between 0.018 and 0.065, while the overbank roughness values varied between 0.065 and 0.072. The channel roughness values used for Rocky Arroyo Creek varied between 0.055 and 0.08. Overbank roughness values ranged from 0.055 to 0.08.

Contraction and expansion coefficients of 0.1 and 0.3 were used for open-channel sections. Contraction coefficients of 0.3 to 0.5 were used at culverts and bridges, depending on the configuration.

Analyses of the hydraulic characteristics of flooding from the sources studied were performed to provide estimates of the elevations of floods of the selected recurrence intervals. Users should be aware that flood elevations shown on the FIRM represent rounded whole-foot elevations and may not exactly reflect the elevations shown on the Flood Profiles or in the Floodway Data tables in the FIS report. Flood elevations shown on the FIRM are primarily intended for flood insurance rating purposes. For construction and/or floodplain management purposes, users are cautioned to use the flood elevation data presented in this FIS in conjunction with the data shown on the FIRM.

The hydraulic analyses for this study were based on unobstructed flow. The flood elevations shown on the profiles are thus considered valid only if hydraulic structures remain unobstructed, operate properly, and do not fail.

As a result of this restudy, Table 1, Summary of Discharges, for detailed-study streams, has been revised. In addition, Table 3, Floodway Data, and the Flood Profiles (Exhibit 1) for the above-mentioned flooding sources have either been revised or added.

All elevations are referenced to the NGVD. ERMs and their descriptions are shown on the maps. ERMs shown on the FIRM represent those used during the preparation of this and previous FISs. The elevations associated with each ERM were obtained and/or developed during FIS production to establish vertical control for determination of flood elevations and floodplain boundaries shown on the FIRM. Users should be aware that these ERM elevations may have changed since the publication of this FIS. To obtain up-to-date elevation information on National Geodetic Survey (NGS) ERMs shown on this map, please contact the Information Services Branch of the NGS at (301) 713-3242, or visit their website at www.ngs.noaa.gov. Map users should seek verification of non-NGS ERM monument elevations when using these elevations for construction or floodplain management purposes.

The NFIP encourages State and local governments to adopt sound floodplain management programs. To assist in this endeavor, each FIS provides 100-year floodplain data, which may include a combination of the following: 10-, 50-, 100-, and 500-year flood elevations; delineations of the 100-year and 500-year floodplains; and 100-year floodway. This information is presented on the FIRM and in many components of the FIS, including Flood Profiles, Floodway Data tables and Summary of Stillwater Elevation tables. Users should reference the data presented in the FIS as well as additional information that may be available at the local community map repository before making flood elevation and/or floodplain boundary determinations.